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[Valovoye sodevzhaniye urana, radiya i toriya v nekotorykh pochvoobrazuyushchikh porodakh]

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THE BULK CONTENT OF URANIUM, RADIUM, AND THORIUM IN CERTAIN SOIL-FORMING ROCKS

D.M. Rubtsov, T.V. Gil'

The content of natural radioactive elements (NRE) in soils is determined by their concentration in the soil-forming rocks from which the soils derive their mineralogic and chemical composition. Therefore, obtaining information on the content of NRE in soil-forming rocks is the most important aspect in investigations to characterize the ecological factor of natural radioactivity (EFNR) and in studies to compile maps and map-diagrams of the content of natural radioactive elements in soils.

Data on the content of NRE are examined in a section of the soil-geographic division of the Komi ASSR (Belyayev et al., 1960) in modern alluvial, ancient alluvial and fluvioglacial deposits, blanket deposits and moraine loams, in the eluvial-deluvial deposits of the Dvinsk, low mountainous-Timan', Pechora and mountainous-Ural'sk soil provinces*). Moreover, a change in the content of NRE in certain deposits which formed under the effect of an excess of water with an elevated NRE content on the day surface is traced.

Uranium was determined by the luminescent (Markov, 1960), radium - by the emmanation (Starik, Schepot'yeva, 1961), and thorium by the photocolorimetric with arsenaso-III (Polyakov, Volynets, 1961) methods.

The alluvial deposits. We examine the deposits of the prechannel flood plain. These are similar to the moraine deposits of the watershed basin with

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respect to their qualitative composition of component minerals (Stenina, 1952). In view of the specific aspects of formation, these deposits are characterized by a high content of the sand fraction and a small amount of mud particles, and as the result of this, by a low content of the sesquioxides and a high content of siliconoxide.

The capacity of absorption calculated per 100 g mud shows that in the colloidal fraction the secondary minerals of the montmorillonite group predominate.

The content of NRE in the given deposits is examined in 2 aspects: first, in the provincial, when these deposits form in different soil-geographic provinces (Dvinsk and Nizkogornaya Timan'), and secondly, taking into account changes in their NRE content during the extrusion of waters containing an increased amount of radium onto the day surface.

The named deposits are distinguished by great fluctuations of the thorium-uranium ratios (Table 1) and by disruption of the radioactive equilibrium between radium and uranium toward an excess of radium.

The alluvial deposits (Table 1) contain uranium and radium in quantities less than the Clark values cited by Vinogradov (1957) for the lithosphere. A tendency toward an increase in the amount of uranium is identified in the Timan' low-mountainous (Nizkogornaya) province with respect to the alluvial deposits of the Dvinsk province.

The amount of thorium in the alluvium of the Timan; province exceeds the geochemical background of the lithosphere by a factor of 2. This is due to the fact that the watershed area encompasses the Timan' ridge, whose bedrocks are enriched with minerals of the thorium group. The cited data indicates the possibility of isolating Timan in an independent geochemical province.

In the case of surface extrusion of the normally moist flood plain soils with waters which contain an increased amount of radium (Table 1), the latter

TABLE 1

CONTENT OF NATURAL RADIOACTIVE ELEMENTS IN SOIL-FORMING ROCKS

Deposits	Soil provinces	Genetic stratum		U, $n.10^{-4}$%	$\frac{Th}{U}$	Ra, $n.10^{-10}$%	$\frac{Ra}{U}$ $n.10^{-7}$	in % of equilibrium	Th, $n.10^{-4}$%
Contemporary alluvial	Dvinsk	"A" x)	D	0,33	56	0.84	25	+855	1,5 xxx)
	Timan' low mountainous	"A"	D	1,20-2,37 1,84	8-15 11	0,89-1,25 0,88	5-8 5	+52-(+89) +58	12,2-20,0 17,3
		"B" xx)	D	0,31-2,52 1,67	5-20 13	0,44-2570,0 635,93	8-10188 2803	+147-(+3034238) +75[illegible]352	13,7-18,0 15,8
Ancient alluvial	Dvinsk	"A"	C	0,42	24	0,23	5	+83	10,0
	Timan' low mountainous	"A"	C	0,79	-	0,43	5	+80	-
		"A"	D	0.50	12	0,57	11	+239	5,8
Covering deposits	Dvinsk	"A"	BC	0,92	5	0,65	7	+108	5,1 xxx)
	Dvinsk	"A"	BC	0,05-1,20 0,92	4-17 10	0,05-0,70 0,67	8-12 8	+72-(+266) +169	21-24 23
		"B"	BC	1,20	8	5,3[illegible]	43	+1173	11,1
Moraine	Timan'	"A"	BC	0,56-1,74 1,15	8-16 12	1,00-1,05 1,02	8-19 14	+193-(+456) +318	8,7-12,6 10,6
		"B"	BC	1,28	12	2,75	21	+538	16,0
	Pechora	"A"	BC	0,70-1,24 1,01	8-11 7	0,19-0,89 0,49	3-8 5	-10-(+63 +42	4,7-11,0 8,3

x) "A" - Soils with geochemical background of NRE content

xx) "B" - Soils formed under the effect of excess water with an increased content of NRE on the day surface.

xxx) - Obtained by calculation according to content in separate mechanical fractions.

is concentrated in the upper part of the soil profile. A partial exception to this rule is the flood plain sod-gley soils of the meso-lowlands, where a washout aqueous regime has predominated for a long period of time, due to melt waters and atmospheric precipitation standing, and therefore a tendency of movement of radium from the initial point of its concentration to the lower layers of the alluvial deposits is observed with subsequent exclusion into the ground water.

The ancient alluvial deposits are loose sands with a high content of SiO_2 and a small amount of the sesquioxides, with respect to granulometric composition. With a similarity of the spectra of the mechanical composition of the alluvial and ancient alluvial deposits, the latter are characterized by a decrease in the content of sesquioxides and low capacity of mud absorption.

There are some 4-7 times less uranium and 2-3.5 times less radium in the ancient alluvial deposits than the accepted Clark values of these elements for the lithosphere. The content of thorium somewhat exceeds the Clark value. The amount of radium in the examined deposits of the Dvinsk province corresponds to the content of radium obtained for the dune deposits of Estonia (Baranov, Morozova et al., 1966).

The absolute values of the content of uranium and radium in the ancient alluvial deposits of the Dvinsk and Timan' provinces are below their content in the alluvial deposits of the same region. The noted tendency has a direct relationship with the low capacity of absorption and the decrease in content of sesquioxides.

The thorium-uranium ratios in the ancient alluvial deposits fluctuate within quite broad limits, and their absolute values are near the ratios cited for the alluvial deposits. In the examined deposits, the radioactive equilibrium between radium and uranium is disrupted toward excess radium (+ 60%).

The fluvioglacial deposits. These are deposits of the outwash plains, the edge fascia of the retreating glacier. According to mechanical composition

they are loose and adherent sands. Unlike the alluvial and ancient alluvial deposits, they are characterized by a reduced content of siliconoxide and an increased amount of the sesquioxides.

The content of uranium and radium (Table 1) is lower, while thorium is somewhat higher than their respective Clark values in the lithosphere. In certain mechanical fractions, a tendency toward an increase in the amount of uranium, thorium, and humus is identified with a reduction in the diameter of the fractions.

The blanket deposits. According to their origin, these are secondary lithologic derivates of moraine (Gerasimov, Shchukevich, 1939). They are characterized by a relatively elevated content of the mud fraction against a predominant background of the large dust-like part of the spectrum. Judging by the absorption capacity (Zaboyeva, 1958; Rubtsov, 1968), the secondary minerals are represented by the montmorillonite and beidellite group.

The amount of uranium and radium in the blanket deposits of the Dvinsk soil province (Table 1) is lower, while that of thorium is 2 times higher than the accepted geochemical background for the lithosphere.

Consequently, a common property of the blanket loams is a reduced content of uranium and an increased content of thorium. In the Timan' province, an increase in the amount of thorium is more significant than in the deposits of the Dvinsk province.

During extrusion of water containing an increased amount of radium to the soil surface, the radium is basically absorbed in the upper part of the soil layer. Nevertheless, its concentration in the BC stratum reaches $5.38 \cdot 10^{-10}$%, i.e., exceeds the Clark value of the lithosphere by nearly 6 times. Thence it follows that in a washout aqueous regime and with good filtration capacity of the dusty loams, the most mobile NRE such as radium migrate slowly and in small amounts to the deep strata of the soil layer.

The moraine deposits are characterized by a reduction in the sandy part of the spectrum against a predominantly large dust-like particle background, a consequence of which is an increase in the content and a drop in the amount of the sesquioxides. The absorption capacity of the mud reaches 70 mg - equiv. per 100 g, which corresponds to the absorption capacity of minerals of the montmorillonite and beidellite group.

The amount of uranium in the moraine deposits of the Timan' and Pechora provinces is below the geochemical background of the lithosphere (Table 1). In the moraine deposits of Timan', the amount of radium is somewhat higher, while it is 2 times lower than the Clark value of the lithosphere in the moraine of the Pechora lowlands. The content of radium and thorium in the moraine deposits of the Pechora lowland, almost coincides with that in the noncarbonate moraine of Estonia (Baranov, Morozova, et al., 1966; Morozova, 1966). The content of thorium in the moraine of the Pechora lowlands is near the geochemical background, while it is one and a half times higher than the Clark value of the lithosphere in the Timan'moraine.

The thorium-uranium ratios are higher in the Timan' moraine than in the corresponding deposits of the Pechora province. This is the result of an increase in the content of thorium in the moraine deposits of Timan'. The radium-uranium equilibrium is disrupted with respect to an excess in radium, and its shift is greatest in the deposits of Timan' and least in the Pechora moraine.

Extrusion to the surface of the soil of waters with a high radium content (Table 1) shows that radium is primarily absorbed in the upper part of the soil layer. After 15-20 years following the end of extrusion of water to the surface of the soil, radium is found in the zone of soil-forming rocks in amounts which exceed its content in the background regions by 3 times. This confirms the hypothesis that under conditions of a washing aqueous regime, radium, albeti in small quantities, still migrates from the zone of initial accumulation.

Uranium, radium, and thorium are contained in all the mechanical fractions of the moraine deposits. A tendency toward a relative accumulation in the mud fraction (<0.001 mm) is noted for uranium and thorium.

The eluvial-deluvial deposits of bedrock. In the Timan' soil-geographic province, the eluvial-deluvial deposits are represented by weathering products of ancient rocks. By their mechanical content, these are light and medium clays with a predominance of large dust particles against a background of an increased content of the mud fraction. They are characterized by a relative increase in the content of SiO_2, and a reduced amount of R_2O_3 with a low capacity of absorption.

The amount of radium fluctuates at the level of the geochemical background of the lithosphere, while that of uranium is somewhat below the background (Table 2).

In regions not disrupted by tectonic phenomena, the amount of thorium exceeds the Clark value of the lithosphere by an average of 4-5 times. In places of tectonic disruptions, its content may exceed the geochemical background by an average of 13-15 times.

The thorium-uranium ratio (Table 2) fluctuates from 8 to 200, and in this case a maximum value is noted in the eluvial-deluvial deposits of the zone of tectonic fractures, and the minimum - in deposits which did not undergo these phenomena.

In the given deposits, radioactive equilibrium has been disrupted between radium and uranium toward an excess in radium. It is characteristic that the equilibrium shift toward the excess in radium in the soil formed in these deposits is even more sharply pronounced. On the one hand, this is due to the high biological mobility of radium, and on the other to the transport of mobile forms of uranium under conditions of the washout aqueous regime.

Uranium, radium, and thorium are contained in all the mechanical fractions. During a comparison of the eluvial-deluvial deposits in the regional regard

TABLE 2.

CONTENT OF NATURAL RADIOACTIVE ELEMENTS IN THE ELUVIAL-DELUVIAL DEPOSITS (IN MELKOZEM, PARTICLES < 1 mm, BY CALCINED WEIGHT)

soil province	number of sections	stratum	U, n.10^{-4}%	$\frac{Th}{U}$	Ra, n.10^{-10}%	$\frac{Ra}{U}$ n.10^{-7}	Ra/U in % of equilibrium	Th, n.10^{-4}%
Timan' low mountainous	9	BC	1,12-3,16[x] / 2,28	8-201 / 46	0,68-1,24 / 0,99	2-9 / 5	-26-(+87) / +23	19,0-427,0 / 93,8
Northern Urals	10	BC	2,94-9,00 / 5,19	1-4 / 3	1,32-6,64 / 2,91	3-9 / 5	-13-(+183) / + 59	10,0-27,3 / 14,5
Polar Urals	5	BC	1,16-13,0 / 5,35	4-104 / 45	0,75-10,4 / 4,54	3-22 / 9	-1-(+557) / +167	23,0-230,0 / 116,0

x) Fluctuations are in the numerator, while the arithmetic mean is in the denominator

it is found that the amount of physical clay in them increases from the mountain-tundra (5-14%) to the mountain-forest strip (20-40%), which is the result of the nonuniformity of processes of physical and physico-chemical weathering and soil formation within limits of vertical zonality. The relative content (in %, taking into account % of the fraction) in the fraction of physical clay of uranium, radium, and thorium changes from 11 to 20 to 50%, in the same direction.

In the melkozem of the eluvial-deluvial deposits of the Northern Urals of light mechanical composition, the amount of uranium averages 2 times higher than the geochemical background of the lithosphere, while that of radium is 3 times higher and that of thorium 1 and a half times higher. The absolute contents (Table 2) of uranium and thorium are higher in the sands and sandy loams than in the medium and heavy loam deposits. On the other hand, radium is contained in large amounts in the eluvial-deluvial deposits of the sandy loam of mechanical composition. The character of change in the content of uranium and thorium from the light rocks to the heavier rocks is not in agreement with the data given by V.I. Baranov, B.G. Morozova et al. (1966) for the moraine deposits. Such a lack of correspondence is explained in the anomalous content of NRE and their richness in primary minerals in comparison with the moraine, as a result of which various aspects of the chemical properties of uranium and thorium appear with predominance of the physical or physico-chemical weathering in different bioclimatic zones.

An examination of the content of NRE in the regional aspect enables one to note the following: 1. the eluvial-deluvial deposits of the Northern Urals have an increased content of NRE over the geochemical background of the lithosphere: uranium is one and a half - 2 times, radium 3-4 times, and thorium 1 and a half - 2 and a half times higher, i.e., the given territory is characterized by an anomalous content of NRE.

2. The relative content of NRE in the fraction of physical clay of the eluvial-deluvial deposits of the mountain-tundra and mountain-forest regional strips has a zonal character, i.e., as the result of an increase in the fraction

of physical clay from the mountain-tundra to the mountain-forest soils there is a respective increase in the amount of NRE found in them.

The eluvial-deluvial deposits of the Polar and Northern Urals are compared in the regional regard. The eluvial-deluvial deposits of the Polar Urals are products of weathering of metamorphic rocks primarily represented by the chlorite-sericite, quartz-sericite-chlorite and other schists. With respect to mechanical composition, these are sandy loams and light loams.

The absolute content of uranium, radium, and thorium (Table 2) is near that of the deposits of the Northern Urals and also exceeds the geochemical background of the lithosphere with respect to uranium by one and a half times, and radium by 5 times. The content of thorium exceeds the Clark value of the lithosphere by an average of 20 times. Consequently, the eluvial-deluvial deposits of the Polar Urals have a multicomponent composition of natural radioactive elements and in this case thorium has the leading role.

The Northern and Polar Urals are a geochemical region with respect to the content of NRE. But certain of its parts are not uniform with respect to their content of NRE. Thus, within limits of the examined territory, it is possible to isolate the Northern Urals as a geochemical region with an increased content of uranium, radium, and thorium, and the Polar Urals as a geochemical thorium region.

In the eluvial-deluvial deposits of the Northern and Polar Urals, radioactive equilibrium is disrupted between radium and uranium with respect to excess radium. In the soils formed in these deposits, the excess of radium is even higher. The observed differences in the shift in equilibrium between the deposits and soil are due to characteristics of soil formation.

NRE are contained in all the mechanical fractions of the eluvial-deluvial deposits of the Urals. In the deposits of the light mechanical composition (sand, loam), characteristic for the mountain-tundra zone, uranium, radium, and thorium are basically contained in the fraction of physical sand. In the

mountain-forest zone and in the loam deposits, the greater part of the NRE are linked with the fraction of physical clay.

In the melkozem of the eluvial-deluvial deposits, a tendency toward direct correlation in the content of organic matter and NRE in the fraction of mud is noted, i.e., the higher the content of humus in the mud the greater its content of radium, uranium, and thorium.

In conclusion, the following should be noted: the alluvial and ancient alluvial deposits have aspects of similarity with the deposits which comprise the watershed basin with respect to the content of NRE. Therefore, a tendency toward an increase in the content of thorium was identified for the Timan' region.

In the alluvial and ancient alluvial deposits, the radium-uranium equilibrium is disrupted with respect to excess radium.

The blanket and moraine deposits of the Timan' region are enriched with thorium, while the deposits of the Pechora lowlands contain thorium within limits of the Clark values of the lithosphere.

Uranium, radium, and thorium are contained in all mechanical fractions of the examined deposits.

The eluvial-deluvial deposits of the Polar and Northern Urals contain uranium, radium, and thorium above the Clark values of the lithosphere, i.e., the territory of the Urals may be assigned to a region with a relatively high content of NRE.

The content of NRE in the fraction of physical clay has zonal aspects.

REFERENCES

1. Baranov, V.I., N.G. Morozova, K.G. Kunasheva, G.I. Grigor'yev. Yestestvennaya radioaktivnost' podzolistykh i dernovo-podzolistykh pochv Estonkoy SSR. (Natural Radioactivity of Podzol and Turf-podzol Soils

of the Estonian SSR.) Sb. trudov Estonskoy s/kh Akademii, trudy po pochvovedeniyu. (A Collection of Transactions of the Estonian Agricultural Academy, Transactions in Soil Sciences) Vol. 49, Tartu., 1966.

2. Belyatev, S.V. et al. Pochvenno-geograficheskiye rayony Komi ASSR. (Soil Geographic Regions of the Komi ASSR.) Izvestiya Komi filiala VGO, No. 6, 1960.

3. Vinogradov, A.P. Geokhimiya redkikh i rasseyannykh khimicheskikh elementov v pochvakh. (The Geochemistry of Rare and Dispersed Chemical Elements in Soils.) Published by the Academy of Sciences of the SSSR, Moscow, 1957.

4. Gerasimov, I.P., M.M. Shukevich. Petrograficheskiy sostav nekotorykh tipov pochvoobrazuyushchikh nanosov SSSR. (The Petrographic Composition of Certain Types of Soil-forming Sediments of the SSSR.) Problemh sovetskava pochvovedeniya. (Problems of Soviet Agronomy.) Collection VIII, 1939.

5. Zaboyeva, I.V. Gleyevo-podzolistyye pochvy. (Gley-podzol Soils.) Pochvovedeniye. No. 3, 1958.

6. Markov, V.I. et al., Uran, metody yego opredeleniya. (Uranium, Methods of Its Determination.) Moscow, Atomizdat, 1960.

7. Morozova, N.G. Opyt sostavleniya kart soderzhaniya yestyestvennykh dolgozhivuschikh radioelementov v pochvakh Estonskoy SSR. (A Method of Compiling Maps of the Content of Natural Long-Lived Radioactive Elements in the Soils of the Estonian SSR, Sb. trudov Est. s/kh akademii, trudy po pochvovedeniyu, Vol. 49, Tartu., 1966.

8. Polyakov, A.N., M.P. Volynets. Opredeleniye toriya fotometricheskim metodom s arsenazo III. (Fluorimetric Determination of Thorium with Arsenaso-III.) Geokhimiya, No. 5, 1961.

9. Rubtsov, D.M. Pochvy Udorskogo rayona Komi ASSR. (Soils of the Udorsk Region of the Komi ASSR.) Dissertatation, KFAN, SSSR Funds. 1959.

10. Rubtsov, D.M. Gleyepodzolistyye pochvy Tritiman'ya. (Gley-podzol Soils of Pretiman'.) Rota-print. KFAN SSSR, Syktyvkar. 1968.

11. Starik, I.Ye., Ye.S. Shchepot'yeva. Oprebeleniye radiya v rudakh i gornykh porodakh. (The Determination of Radium in Ores and Rocks.) Metody opredeleniya RE v mineral'nom syr'ye. (Methods of Determining Radioactive Elements in Mineral Raw Materials.) Gostekhivdat, Moscow, 1961.

12. Stenina, T.A. Pochvy srednego techeniya reki Vychegdy. (Soils of the Mid-Course of the Vychegda River.) KFAN SSSR Funds, 1952.